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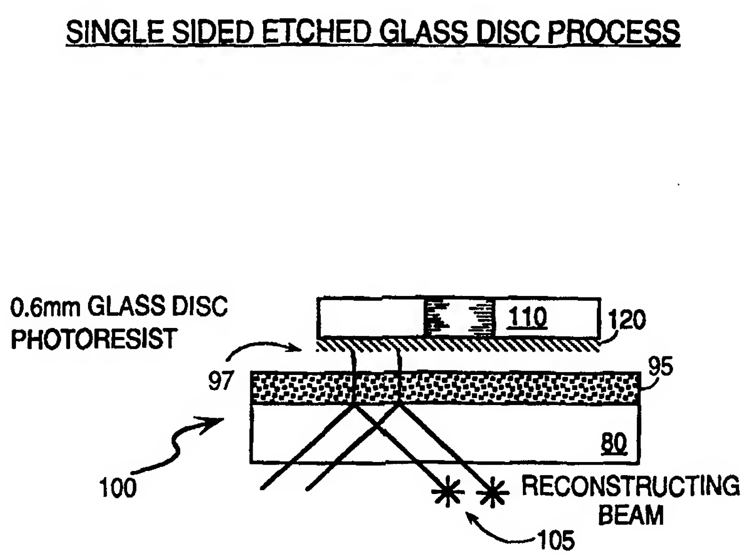

(57) Abstract

A servo patterned disk and method for making the disk. The disk substrate is made of a rigid material such as glass, plastic, or metal. The servo pattern is formed using a process wherein a high contrast mask of the servo pattern is made and then used to create a hologram template. The hologram template is then used to create a real image of the high contrast mask on the substrate surface from which substrate material is removed to form the servo pattern. The pattern can be generated in both sides of the disk if desired.

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AN ETCHED GLASS DISK PROCESS

REFERENCE TO RELATED APPLICATION

This application claims the benefit of U.S. Provisional Application No. 60/084,514.

FIELD OF THE INVENTION

This invention relates to the field of optical disk drives and, more specifically, to a method of manufacturing substrates used in optical disk drives.

BACKGROUND

Rigid disk drives based on Winchester technology are used in mainframe, desktop, and portable computers as direct access memory storage devices. Data is stored in annular regions on one or more disks of the disk drive. These disks also contain servo information that allows the disk drive to correctly position disk head circuitry to store and retrieve the data.

The servo information can be located in different areas of the disk. A sector servo system contains the servo information intermingled with the stored data on the same disk surface and is read by the data heads. A dedicated servo system contains servo information on a dedicated disk surface and is read by a dedicated servo head. This dedicated disk surface can be on a dedicated disk (i.e., separate from the data disk) or on a data disk located on the opposite side from the data surface. A buried servo system contains servo information written vertically in the same data surface of the data disk, thereby increasing space on the disks for data recording. While a separate servo disk is more expensive, it speeds up access time because the data heads do not spend time on servo information.

The storage and retrieval of data on the disks is accomplished by the data (i.e., read/write) heads. These heads are positioned over the desired data location by the position control system of the disk drive based on the

servo information. The servo information enables the disk drive to correct head positioning due to factors such as head tilt and thermal expansion.

Newer optical disk drive systems use laser technology to assist Winchester disk drives in data storage and retrieval. These optical disk drives use optics for servo positioning and magnetics for recording and reading. Laser beams are used to read servo information encoded on a layer of a disk. This servo information is encoded in the form of pits in the substrate of the disk. The pits are depressions that can be less than 0.2 micrometers in depth and vary in length and width based on the information content. Information is read from this pit layer by using laser beams to detect the difference in depth between the pits and the land (i.e. unpitted surface). The servo system uses this information to maintain focus and tracking of the disk drive heads. However, the performance of the servo system can be affected by the substrate material used in manufacturing the disks.

Disk substrates can be made from different materials such as aluminum, plastic, or glass. One problem with prior art systems is the choice of material used for the disk substrate. Materials can be chosen based on cost, mechanical performance, and disk drive power requirements. For example, the less the mass of the disk, the less power is actually required in the motor to rotate the disks and less induced vibration occurs.

Some prior systems use metal substrates such as aluminum because metals can rotate at high speeds and, thus, improve data access time. However, metals are heavier than other materials and, thus, require more power to rotate.

Other prior art systems use a plastic substrate where a pit pattern is replicated in the substrate using an injection molding process. In an injection molding process, the pit pattern is created in a metal sheet, typically electroform nickel, and then molten plastic is injected and molded against that nickel surface. The plastic cools down and conforms to the shape of the nickel surface as it solidifies. When the plastic is separated from the nickel, the plastic surface has the pit pattern molded in it. The

quality of the pit pattern is determined to a great extent by the molding process and the type of plastic used.

Although the use of plastic provides a weight advantage over using metal, conventional plastic materials may not be able to be cleaned and polished due to their softness. The ability to polish the disk substrate surface and clean (i.e., wash out) the pits in the disk substrate is advantageous for reducing defects on the disk which could cause problems resulting in head positioning errors. In addition, using a plastic substrate requires an initial layer of aluminum on top of the plastic to function as a heat sink. Eliminating the need for this layer can improve the noise performance of the disk substrate.

Another prior art system uses higher performance plastic substrates. However, when using higher performance plastics it becomes very difficult to reproduce the very small surface features required for the pit pattern using an injection molding process while still maintaining critical attributes of the disk such as disk flatness.

One prior art system based on Winchester (non-optically assisted) technology uses a glass substrate. The advantages of using glass instead of plastic are that glass is more flat, stiff, scratch resistant, temperature resistant, humidity resistant, chemical and solvent resistant, heat dissipating, and easier to machine, polish and clean. The prior art system using a glass substrates, however, did not etch a servo pattern into the glass substrate. Rather, the Winchester technology prior art system applied a magnetic layer on top of the glass substrate and then encoded the servo pattern into this magnetic layer. Encoding the servo pattern into the magnetic layer can be time consuming, thereby adding to the cost of high volume manufacturing.

Therefore, it is desirable to have a method of producing servo patterns in disk substrates that addresses these problems.

SUMMARY OF THE INVENTION

The present invention pertains to a method of manufacturing a pattern in a substrate. The substrate pattern is formed using a process wherein a mask is produced to generate a hologram template. The hologram template is used to generate the pattern in the substrate based on real images of the mask.

Additional features and advantages of the present invention will be apparent from the accompanying drawings and from the detailed description that follows.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention is illustrated by way of example, and not by way of limitation, in the figures of the accompanying drawings and in which like reference numerals refer to similar elements and in which:

Figures 1A through 1D illustrate a method for generating a high contrast mask.

Figure 1A illustrates using a laser to expose areas of photoresist applied on top of a master covered with an opaque layer.

Figure 1B illustrates removing the exposed areas of the photoresist of the master to form a pit pattern in the photoresist.

Figure 1C illustrates removing the opaque layer underneath the exposed pit pattern in the photoresist.

Figure 1D illustrates removing the residual photoresist leaving the pit pattern of the opaque layer intact on the master.

Figures 2A and 2B illustrate a method for generating a hologram template using the high contrast mask of Figure 1D.

Figure 2A illustrates using the high contrast mask of Figure 1D to record an image in a photopolymer of the hologram template.

Figure 2B illustrates the photopolymer containing a holographic image produced where two light beams interfere.

Figures 3A through 3D illustrate a method for generating a pit pattern in the substrate using the hologram template of Figure 2B.

Figure 3A illustrates the hologram template of Figure 2B placed adjacent to the substrate having a photoresist thereon, where the photopolymer of the hologram template faces the substrate and a light beam is directed through the hologram template such that a real image is created in the photoresist of the substrate.

Figure 3B illustrates exposing a pit pattern in the photoresist of the substrate.

Figure 3C illustrates removing areas of the substrate underneath the pit pattern of the photoresist creating a pit pattern in the substrate.

Figure 3D illustrates removing the remaining photoresist leaving the substrate with a flat surface containing the pit pattern.

Figures 4A through 4D illustrate an embodiment of the present invention where pit patterns are generated in both sides of a substrate using two hologram templates.

Figure 4A illustrates the substrate, coated on both sides with a photoresist, positioned between two hologram templates. Light beams are directed through the hologram templates to expose areas of the photoresist on the substrate.

Figure 4B illustrates removing the exposed areas of the photoresist on both sides of the substrate.

Figure 4C illustrates removing areas of the substrate underneath the exposed areas in the photoresist.

Figure 4D illustrates removing the residual photoresist leaving a pit pattern in both sides of the substrate.

Figures 5A through 5D illustrate an alternative method for generating a high contrast mask using a lift-off technique.

Figure 5A illustrates using a laser to expose areas of photoresist applied on top of a master.

Figure 5B illustrates removing the exposed areas of the photoresist forming a pit pattern in the photoresist.

Figure 5C illustrates applying an opaque layer over the photoresist and the master.

Figure 5D illustrates removing the photoresist and areas of the opaque layer on top of the photoresist.

Figures 6A and 6B illustrate an alternative method for generating a high contrast mask using a laser lithography technique.

Figure 6A illustrates using a laser to remove areas of an opaque layer applied on top of a master.

Figure 6B illustrates a master with a pit pattern formed in the removed areas of the opaque layer.

Figure 7 illustrates a disk drive system containing one or more disks with a servo pattern generated using the process of the present invention.

DETAILED DESCRIPTION

A method for producing a pattern etched into a substrate surface is described in which a high contrast mask of the pattern is used to create a hologram template to mass produce real images of the pattern in disk substrates. In the following description, numerous specific details are set forth such as examples of specific materials, process steps, process parameters, dimensions, etc. in order to provide a thorough understanding of the present invention. It will be obvious, however, to one skilled in the art that these specific details need not be employed to practice the present invention. In other instances, well known materials or methods have not been described in detail in order to avoid unnecessarily obscuring the present invention.

The method below describes etching servo patterns into a disk substrate. Although use of a glass substrate is advantageous due to its optical characteristics (i.e., transparent to light) and its physical robustness, the method described can be used with substrates made of other materials such as metal, ceramic, and plastic. Furthermore, the method described below is not limited to only servo patterns but can be used to create other types of patterns in substrates.

The method for producing the pit pattern into the substrate surface is achieved in a three stage process: a high contrast mask generation stage, a hologram template generation stage, and a substrate pit pattern generation stage. Once the hologram template generation stage is completed, the hologram template may be used repeatedly to mass produce substrates with the pit pattern.

Figures 1A through 1D illustrate the high contrast mask process stage of the present invention. The process begins in Figure 1A, with a piece of glass known as a master 10. Master 10 must be optically transparent to the wavelength of the light used in the recording process described below. In one embodiment, master 10 is constructed from quartz. In other embodiments, master 10 is constructed from other generally transparent or translucent glass materials.

In Figure 1A, master 10 is polished on both sides and coated with a layer of opaque material 20 such as titanium nitride (TiN). In one embodiment of the present invention, the thickness of opaque layer 20 is approximately 200 nanometers. However, the thickness can range from approximately 50 - 500 nanometers in other embodiments. In other embodiments, master 10 can be coated with other opaque materials that block the passage of light, for examples: aluminum, chromium, and gold.

A photoresist 30 is applied on top of opaque layer 20. It should be noted that the properties of photoresist materials are well known to those skilled in the art and, therefore, the details are not described herein. Photoresist 30 is then recorded on (i.e., exposed) using a laser beam recorder (LBR)(not shown) whereby a light beam 15 is modulated (i.e., switched on and off) as it is scanned across photoresist 30 to produce areas of exposure and areas of non-exposure. In one embodiment, the master is rotated while a stationary LBR records the area of exposure. In one embodiment, light beam 15 is ultraviolet light. In other embodiments, light beam 15 is in another spectrum frequency, for examples: x-ray, infrared, red, and blue. The dimensions of these exposed areas ultimately define the resulting substrate pit pattern described below in Figure 3D.

In Figure 1B, the exposed areas are developed by a wet chemical etching process that exposes a pit pattern 35 in photoresist 30. It should be noted that the wet chemical etching process is well known in the art and, therefore, the details are not described herein.

Photoresist pit pattern 35 is then used to pattern opaque layer 20. In Figure 1C, areas of opaque layer 20 underneath the exposed photoresist pit pattern 35 are removed using a wet chemical etching process that exposes a pit pattern 40 in opaque layer 20. In another embodiment, the areas of opaque layer 20 are removed using a dry etching process. It should be noted that both the wet chemical and dry etching process used to remove opaque layer 20 are well known in the art and, therefore, the details are not described herein.

In Figure 1D, the residual photoresist 30 is removed leaving the pit pattern 40 of opaque layer 20 intact on master 10. The final product of this stage is called a high contrast mask 50. The term high contrast mask means that if one were to direct light through master 10, light would only come out through regions of pit pattern 40 and no light would be transmitted through areas of master 10 covered by opaque layer 20.

In another embodiment, a lift-off technique is used to used to generate high contrast mask 50. An example of a lift-off technique is described in further detail below in regards to Figures 5A through 5D.

Figures 2A and 2B illustrate the hologram template process stage of the present invention. Figure 2A illustrates the portion of the process that is used to record a holographic image of the high contrast mask 50 of Figure 1D. The high contrast mask 50 is positioned adjacent to a piece of glass, known as a hologram plate 80, coated on one side with a photopolymer 90. In one embodiment, hologram plate 80 is constructed from quartz. In other embodiments, hologram plate 80 is constructed from other generally transparent or translucent glass materials. It should be noted that the properties of photopolymers are well known to those skilled in the art and, therefore, the details are not described herein.

As shown in Figure 2A, the side of high contrast mask 50 having opaque layer 20 is positioned towards the side of hologram plate 80 having photopolymer 90. A object beam 60 is directed, at approximately a 90 degree incident angle, through high contrast mask 50 towards the side of hologram plate 80 coated with photopolymer 90. Simultaneously, a reference beam 70 is directed through the uncoated side of hologram plate 80 and interferes with object beam 60 in photopolymer 90. It should be noted that the size of beams 60 and 70 can be relatively large compared to pit pattern 40 of Figure 1D.

In one embodiment, reference beam 70 is directed at approximately a 45 degree incident angle. In other embodiments, reference beam 70 is incident at other angles such that full internal reflection is achieved while maintaining interference of beams 60 and 70 at photopolymer 90 without distortion of the holographic image of Figure 2B. In one embodiment, beams 60 and 70 are ultraviolet lights. In other embodiments, beams 60 and 70 are beams of light in other spectrum frequencies, for examples: x-ray, infrared, red and blue.

Figure 2B shows a photopolymer 95 containing a holographic image 92 that is produced where object beam 60 and reference beam 70 interfere. The output of this stage is a hologram template 100 made of hologram plate 80 and photopolymer 95 containing a holographic image 92 of the original high contrast mask 50 of Figure 1D.

Figures 3A through 3D illustrate the substrate pattern generation stage of the process used to replicate the holographic image 92 of high contrast mask 50 into a substrate 110.

In one embodiment, substrate 110 has a thickness of approximately 0.6 millimeters. In other embodiments, the thickness of substrate 110 can range from approximately 0.3 to 5 millimeters. A photoresist 120 is applied to one of a top and a bottom surface of substrate 110. In one embodiment, substrate 110 is quartz. In other embodiments, substrate 110 is constructed from other glass materials such as soda lime and silica glass. In other

embodiments, substrate 110 is constructed from non-glass materials such as plastic and aluminum.

In Figure 3A, the hologram template 80 is placed adjacent to substrate 100 with photopolymer 95 of hologram template 80 facing photoresist 120 of substrate 110. A reconstruction beam 105 is directed, at approximately a 45 degree incident angle, in a path that is opposite to the path of reference beam 70 of Figure 2A. A real image 97 is created above the surface of photopolymer 95, and substrate 110 covered with photoresist 120 is placed at the interface of real image 97.

As shown in Figure 3A, the reconstruction beam 105 is directed toward the entire surface of photoresist 120 and exposes the photoresist 120 in those areas where, due to real image 97 created therein, reconstruction beam 105 passes through hologram image 92. In one embodiment, reconstruction beam 105 is ultraviolet light. In other embodiments, light beam 105 is in another spectrum frequency, for examples: x-ray, infrared, red and blue.

In Figure 3B, the exposed areas of photoresist 120 are removed creating a pit pattern 125 in photoresist 120. In one embodiment, the exposed areas of photoresist 120 are developed away using a wet chemical etching process. In another embodiment, the exposed areas of photoresist 120 are removed using a dry etching process. As noted above, both the wet chemical and dry etching process are well known in the art and, therefore, the details are not described herein.

Pit pattern 125 is then used to pattern substrate 110. In Figure 3C, areas of substrate 110 underneath pit pattern 125 are removed using a wet chemical etching process that exposes a pit pattern 130 in substrate 110. In one embodiment, a reactive ion etch process is used to etch directly into the substrate 110 surface through pit pattern 125. A reactive ion etch process is well known to those in the art and, therefore, the details are not described herein. In other embodiments, other processes such as plasma etching can be used to etch into substrate 110.

In Figure 3D, the remaining photoresist 120 is removed, leaving substrate 110 with a flat surface containing pit pattern 130. This pit pattern forms the servo pattern that will ultimately be read by a laser mounted on the disk drive head (not shown). In one embodiment, the depth of pit pattern 130 is 650 nanometers. In other embodiments, the depth of the pits is approximately 1/4 the wavelength of the light used to read the pit pattern. It should be noted that the wavelength of the light limits the size of the pit pattern that can be read from the substrate. As the industry moves towards smaller wavelength lasers, the process described herein may be used to create the shallower pit patterns required for use with such lasers.

Another embodiment of the present invention is illustrated in Figures 4A through 4D where pit patterns are generated in both sides of a substrate using two hologram templates. The thickness of substrate 200 is approximately twice as thick as substrate 110 to allow for pit patterns to be etched in both sides of the substrate 200.

Figure 4A illustrates a substrate 200, coated on both sides with photoresists 120, 127, positioned between two hologram templates 300, 400 having photopolymers 395, 495 containing holographic images 392, 492, respectively, of high contrast mask 50 of Figure 1D. The hologram templates 300, 400 are used in a method similar to that described above for Figure 3A that exposes both photoresist 120 and 127. The exposure of the photoresists 120, 127 can either be done simultaneously or sequentially. Real images of hologram templates 300, 400 are created at both photoresist 120, 127 interfaces.

In Figure 4B, the exposed areas of photoresist 120 and 127 are removed using a method similar to that described above for Figure 3B. In Figure 4C, pit patterns 230 and 240 are etched into substrate 200 using a method similar to that described above for Figure 3C.

In Figure 4D, any remaining photoresist 120, 125 is removed leaving substrate 200 with a flat surface containing pit patterns 230, 240 forming the servo patterns.

In one embodiment, holographic images 392 and 492 are similar. In another embodiment, holographic images 392 and 492 are different from each other such that resulting pit patterns 230 and 240 are also different from each other.

In an alternative embodiment, the high contrast mask 50 of Figure 1D may also be generated using a lift-off technique illustrated in Figures 5A through 5D. The materials used are similar to those used in Figures 1A through 1D and, therefore, are not described below.

In Figure 5A, master 510 is polished on both sides and coated with photoresist 530. Photoresist 530 is then recorded on using a LBR (not shown) whereby light beam 515 is modulated as it is scanned across photoresist 530 to produce areas of exposure and areas of non-exposure.

In Figure 5B, the exposed areas are developed by a wet chemical etching process resulting in a photoresist pit pattern 535. As noted above, both the wet chemical etching process is well known in the art and, therefore, the details are not described herein.

Photoresist pit pattern 535 is then used to pattern opaque layer 520. In Figure 5C, an opaque layer 520 is applied over the photoresist 530 and master 510. The thickness of opaque layer 520 is less than that of photoresist 530.

In Figure 5D, photoresist 530 and the areas of opaque layer 520 on top of photoresist 530 are removed using a wet chemical etching process leaving the pit pattern 540 of opaque layer 520 intact on master 510. The final product of this process stage is a high contrast mask 550 similar to the high contrast mask 50 of Figure 1D.

In yet another embodiment, the high contrast mask 50 of Figure 1D may also be generated using a laser lithography technique illustrated in Figures 6A through 6B.

In Figure 6A, master 610 is polished on both sides and coated with opaque layer 630. In one embodiment, opaque layer 630 is tellurium (Te). In other embodiments, opaque layer 630 is an opaque material with a low melting point, for example: antimony, bismuth, indium, or tellurium-

selenium alloys. A laser 615 is modulated as it is scanned across opaque layer 630 removing areas of opaque layer 630 to form pit pattern 640 in opaque layer 630. Laser 615 ablates openings in opaque layer 630 such that light is able to pass through the openings. In one embodiment, laser 615 is an electron beam. In other embodiments, laser 615 is a light beam with a different wavelength, for example: ion beam or x-ray. The final product of this process stage is a high contrast mask 650 similar to the high contrast mask 50 of Figure 1D.

The photoresist described above process is a positive photoresist where the exposed regions become more soluble and, thus, removable in the etching process. In other embodiments, a negative photoresist is used in which the exposed regions become less soluble. Thus the exposure pattern for negative resists is opposite of that for the positive resists.

In other embodiments, dry etching techniques such as plasma etching, active ion etching, or ion milling are used to remove the photoresists, the opaque layer materials, and the substrate materials described above.

It should be noted that glass is just one example of the substrate materials that can be used with the present invention. The use of a glass substrate with sufficient thermal properties may allow for elimination of a noisy aluminum heat sink layer needed for plastic substrates. In other embodiments, different types of materials may be used particularly where there is no requirement for light to pass through the substrate material.

The above described process may also be used on higher performance plastic as a viable way of generating a pit pattern into the surface of stiffer engineered plastics. Thus, one could get an enhanced mechanical performance and weight advantage using the higher performance plastic substrates while having the ability to properly etch and clean the substrate.

The above described process also can reduce servo pattern manufacturing time. The process stage of Figures 1A through 1D can take on the order of four to six hours with the majority of time required in scanning a narrow laser beam across photoresist 30 of Figure 1A to expose

the pattern in photoresist 30. The time is based on the pit pattern density and the rotation speed of the master in relation to the LBR. While the process stage of Figures 3A through 3D can take approximately thirty seconds because a wider laser beam is used to expose the entire surface of the photoresist 120 of Figure 3A. If the process stage of Figures 1A through 1D were used to etch directly into a substrate to create the substrate servo pattern, such a process would take four to six hours to make a single servo patterned substrate. Using the present invention, however, enables one to generate a high contrast mask in approximately four to six hours and a hologram template in approximately 30 minutes. The servo patterned substrates can then be mass produced, each one taking approximately thirty seconds to generate.

For example, to make 1,000 patterned substrates using just the process illustrated in Figures 1A through 1D would take approximately 6,000 hours (1,000 substrates at 6 hours each). If the present invention were used there would be, for example, one 6 hour process to make a hologram template from a high contrast mask and then one thousand 30 second processes (or 8.5 hours) to make the 1,000 patterned substrates. Thus, in the above example, the present invention may potentially make the entire 1,000 patterned substrates in approximately 15 hours.

Figure 7 illustrates a disk drive system 700 containing one or more disks with a servo pattern generated using the process of the present invention. The disk drive generally comprises a drive controller 715, an actuator motor 735, a spindle motor 725, one or more actuator arms 760, one or more optics 780, one or more heads 790, and one or more disks 750. Drive controller 715 contains circuitry to control the position of the heads 790 in relation to disks 750 and generally comprises a head/servo position control module 710, a spindle control module, 720, an actuator control module 730, an optical control module 740. There is a gap between disks 750 that allows heads 790 and optics 780 mounted at the end of actuator arms 760 to move across disks 750 as the spindle motor 725 rotates the disks 750. The actuator arms 760 are moved by actuator motor 735 to position the

heads 790 and optics 780. In one embodiment, one of disks 750 is a dedicated servo disk having a servo pattern generated using the process of the present invention. In another embodiment, one of disks 750 contains both data and a servo pattern generated using the process of the present invention.

As noted above, the present invention is not limited to only generating servo patterns and may be used to generate substrate patterns for other applications, for examples: CD (Compact Disc) and DVD (Digital Video Disc).

In the foregoing specification, the invention has been described with reference to specific exemplary embodiments thereof. It will, however, be evident that various modifications and changes may be made thereto without departing from the broader spirit and scope of the invention as set forth in the appended claims. The specification and drawings are, accordingly, to be regarded in an illustrative rather than a restrictive sense.

CLAIMS

What is claimed is:

1. A method of manufacturing a pattern in a substrate, comprising:

generating a mask;

generating a hologram template based on the mask; and

generating the pattern in the substrate based on the hologram template.

2. The method of claim 1, wherein generating the mask comprises:

applying a first layer and a second layer to a first glass;

selecting areas of the second layer;

removing the second layer in the selected areas;

removing areas in the first layer underneath the second layer removed areas; and

removing the non-selected areas of the second layer.

3. The method of claim 1, wherein generating the hologram template comprises:

applying a photopolymer to a glass; and

recording an image in the photopolymer based on the mask.

4. The method according to claim 1, wherein generating the pattern in the substrate comprises:

applying a first layer to the substrate;

selecting areas of the first layer based on the hologram template;

removing the first layer in the selected areas;

removing areas in the substrate underneath the removed areas in the first layer; and

removing the non-selected areas of the first layer.

5. The method according to claim 1, wherein the substrate has a top and a bottom surface and wherein generating the pattern in the substrate comprises:

applying a first layer to the top and the bottom surface of the substrate;

selecting areas of the first layer on the top and the bottom surface;

removing the selected areas of the first layer;

removing areas in the substrate underneath the removed areas in the first layer; and

removing the non-selected areas of the first layer.

6. The method of claim 2, wherein generating the hologram template comprises:

applying a photopolymer to a second glass; and

recording an image in the photopolymer based on the mask.

7. The method according to claim 6, wherein the substrate has a top and bottom surface and wherein generating the pattern in the substrate comprises:

applying a third layer to the top and the bottom surface of the substrate;

selecting areas of the third layer on the top and bottom surfaces;

removing the selected areas of the third layer;

removing areas in the substrate underneath the removed areas in the third layer; and

removing the non-selected areas of the third layer.

8. The method of claim 1, wherein generating the mask comprises:

applying an opaque material to a top surface of a first glass;

applying a first photoresist on top of the opaque material;

exposing the first photoresist to a first light in selected areas; and

removing the first photoresist in the selected areas;

removing the opaque material in areas underneath the removed areas in the first photoresist.

9. The method of claim 8, wherein generating the hologram template comprises:

applying a photopolymer to a front surface of a hologram plate;

transmitting a second light through a back side of the first glass to the photopolymer wherein the second light passes through the mask in the removed areas of the opaque material; and

transmitting a third light to a back surface of the hologram plate simultaneously with the transmitting of the second light wherein an image is recorded in the photopolymer.

10. The method of claim 9, wherein generating the pattern in the substrate comprises:

applying a second photoresist to a top surface of the substrate;

transmitting a fourth light through a back surface of a hologram plate to the top surface of the substrate wherein areas of the second photoresist are exposed based on the image in the photopolymer;

removing the second photoresist in the exposed areas;

removing areas of the substrate underneath the removed areas of the second photoresist material; and

removing the second photoresist in non-exposed areas.

11. The method of claim 9, wherein the substrate has a top and a bottom surface and wherein generating the pattern in the substrate comprises:

generating a second hologram template having a second photopolymer identical to the hologram template;

applying a second photoresist to the top and the bottom surface of the substrate;

transmitting a fourth light through the hologram template to the top surface of the substrate and through the second hologram template to the substrate bottom surface wherein areas of the second photoresist are exposed corresponding to the images in the photopolymers;

removing the second photoresist in the exposed areas;

removing areas in the substrate underneath the removed areas in the second photoresist; and

removing the second photoresist in non-exposed areas.

12. The method of claim 8, wherein the opaque layer is titanium nitride and wherein the first glass is quartz.

13. The method of claim 9, wherein the hologram plate is quartz.

14. The method of claim 10, wherein the substrate is glass.

15. The method of claim 11, wherein the substrate is glass and the second hologram template is quartz.

16. The method of claim 1, wherein generating the mask comprises:

applying a first photoresist to the a top surface of a first glass;

exposing the first photoresist to a first light in selected areas;

removing the first photoresist in the selected areas;

applying an opaque material on top of the first photoresist and the top surface of the first glass underneath the selected areas; and

removing the first photoresist and the opaque material on top of the first photoresist.

17. The method of claim 16, wherein generating the hologram template comprises:

applying a photopolymer to a front surface of a hologram plate;

transmitting a second light through a back side of the first glass to the photopolymer wherein the second light passes through the mask in the removed areas of the opaque material; and

transmitting a third light to a back surface of the hologram plate simultaneously with the transmitting of the second light wherein an image is recorded in the photopolymer.

18. The method of claim 17, wherein generating the pattern in the substrate comprises:

applying a second photoresist to a top surface of the substrate;

transmitting a fourth light through a back surface of a hologram plate to the top surface of the substrate wherein areas of the second photoresist are exposed based on the image in the photopolymer;

removing the second photoresist in the exposed areas;

removing areas of the substrate underneath the removed areas of the second photoresist material; and

removing the second photoresist in non-exposed areas.

19. The method of claim 1, wherein generating the mask comprises:

applying an opaque material to a top surface of the mask; and

removing the opaque material in selected areas.

20. The method of claim 19, wherein generating the hologram template comprises:

applying a photopolymer to a front surface of a hologram plate;

transmitting a second light through a back side of the first glass to the photopolymer wherein the second light passes through the mask in the selected areas of the opaque material; and

transmitting a third light to a back surface of the hologram plate simultaneously with the transmitting of the second light wherein an image is recorded in the photopolymer.

21. The method of claim 20, wherein generating the pattern in the substrate comprises:

applying a photoresist to a top surface of the substrate;

transmitting a fourth light through a back surface of a hologram plate to the top surface of the substrate wherein areas of the photoresist are exposed based on the image in the photopolymer;

removing the photoresist in the exposed areas;

removing areas of the substrate underneath the removed areas of the photoresist material; and

removing the photoresist in non-exposed areas.

22. A method of manufacturing an optically readable substrate, comprising:

applying an opaque material to a top surface of a first glass;

applying a first photoresist on top of the opaque material;

exposing the first photoresist to a light source in selected areas;

removing the first photoresist in the selected areas;

removing the opaque material in areas underneath the removed areas in the first photoresist;

removing any remaining first photoresist;

coating a front surface of an second glass with a photopolymer;

transmitting a first light source through a back side of the first glass to the photopolymer wherein the light passes through the mask in the removed areas of the opaque material;

transmitting a second light source to a back surface of the second glass simultaneously with the transmitting of the first light source wherein an image is recorded in the photopolymer;

applying a second photoresist to a top surface of the substrate;

transmitting a third light source through the second glass back surface to the substrate top surface wherein areas of the second photoresist are exposed based on the image in the photopolymer;

removing the second photoresist in the selected areas;

removing areas of the substrate underneath the removed areas of the second photoresist; and

removing the second photoresist in non-selected areas.

23. The method of claim 22, wherein the opaque material is titanium nitride.

24. The method of claim 22, wherein the first glass is quartz.

25. The method of claim 22, wherein the second glass is quartz.

26. The method of claim 22, wherein the substrate is glass.

27. A method of manufacturing a patterned substrate, comprising:

means for generating a high contrast mask;

means for generating a hologram template; and

means for generating the substrate pattern based on the hologram template.

28. An optically readable disk, comprising a substrate having a pattern created in the substrate based on a hologram template containing an image of the pattern.

29. The disk of claim 28, wherein the substrate is glass.

30. A disk drive system, comprising:

a head;

an optic; and

a disk having a substrate, the substrate having a pattern based on a hologram template containing an image of the pattern.

31. The disk drive system of claim 30, further comprising a disk controller.

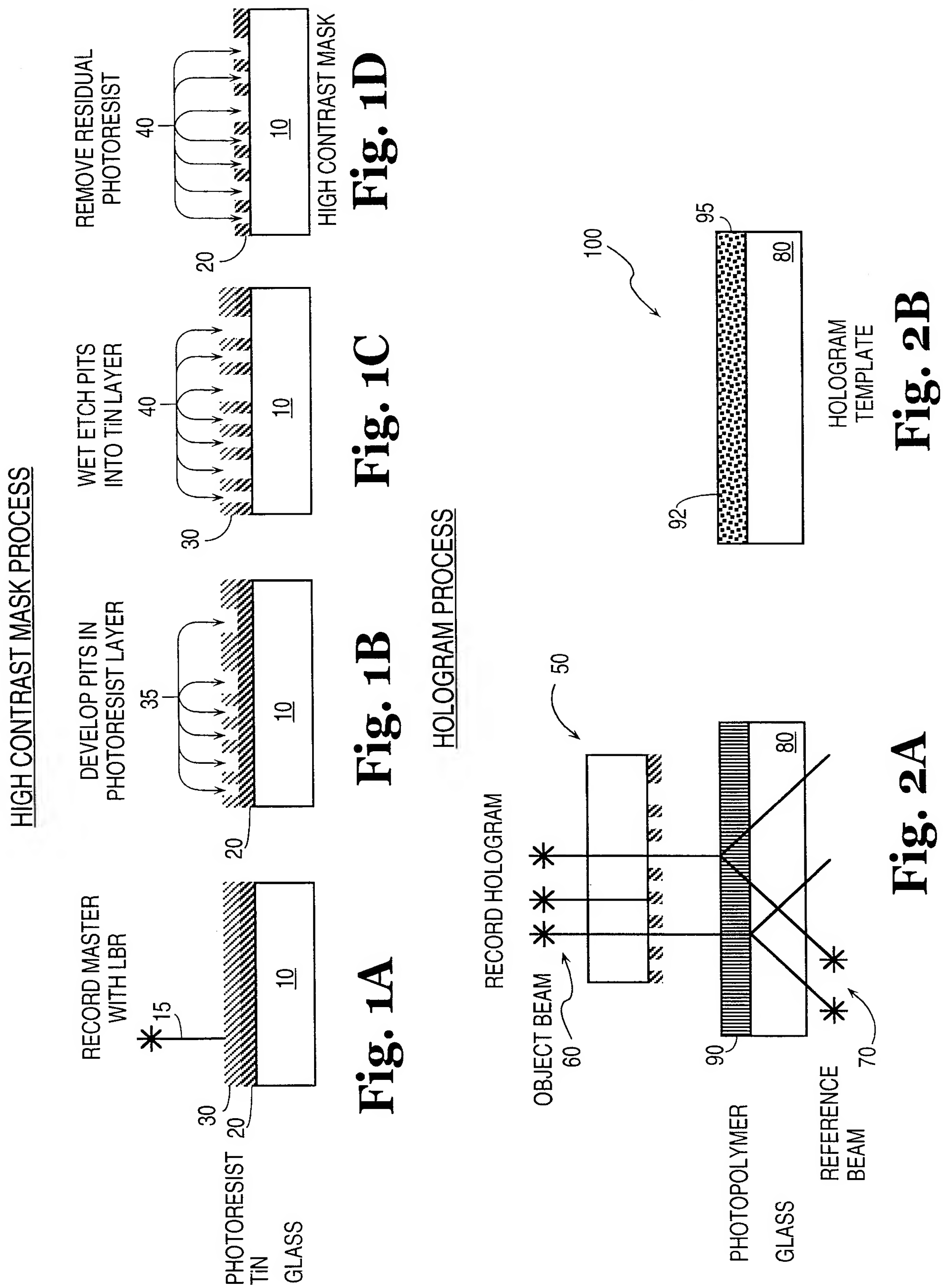

Fig. 1A

Fig. 1B

Fig. 1C

Fig. 1D

Fig. 2A

Fig. 2B

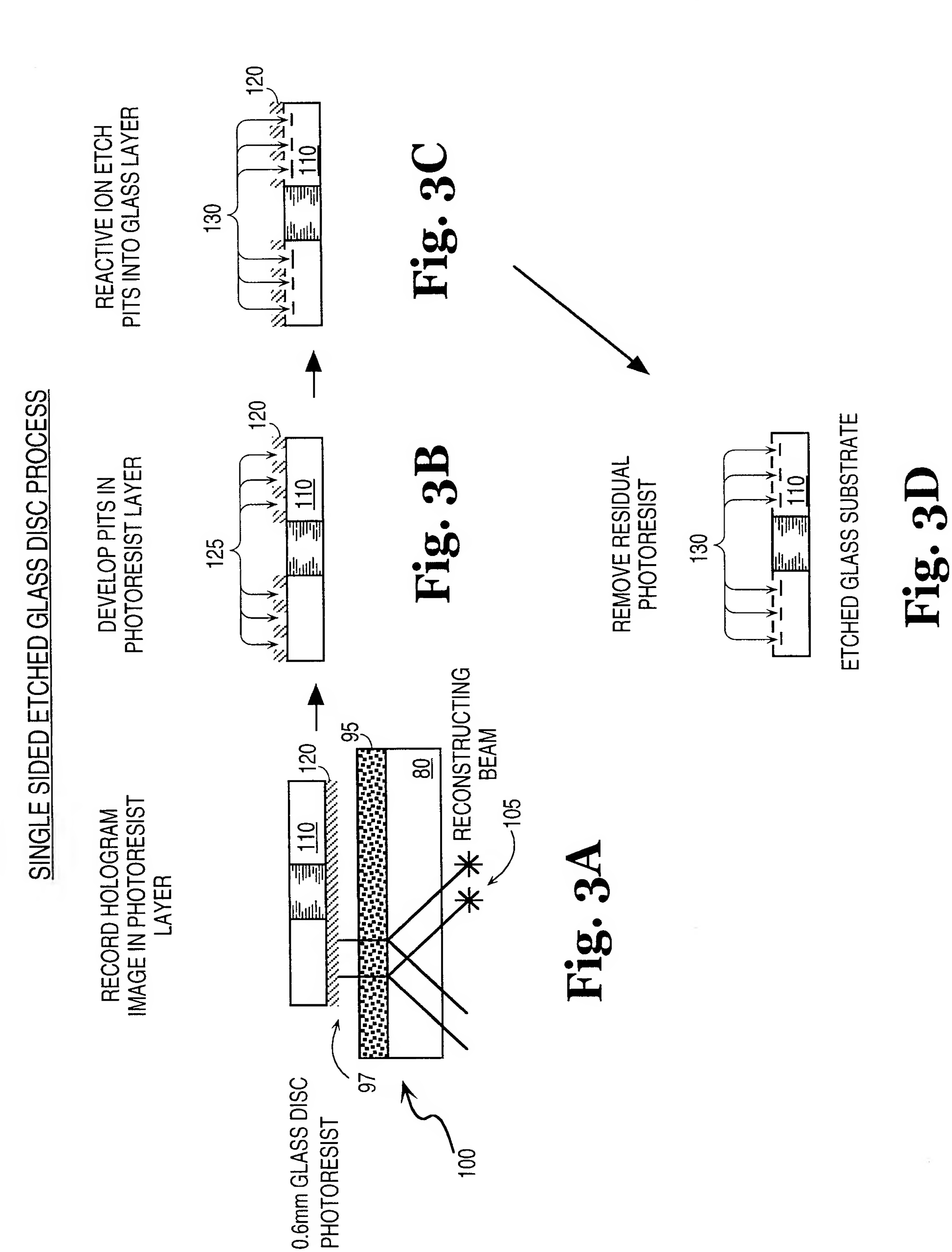

Fig. 3A

Fig. 3B

Fig. 3C

Fig. 3D

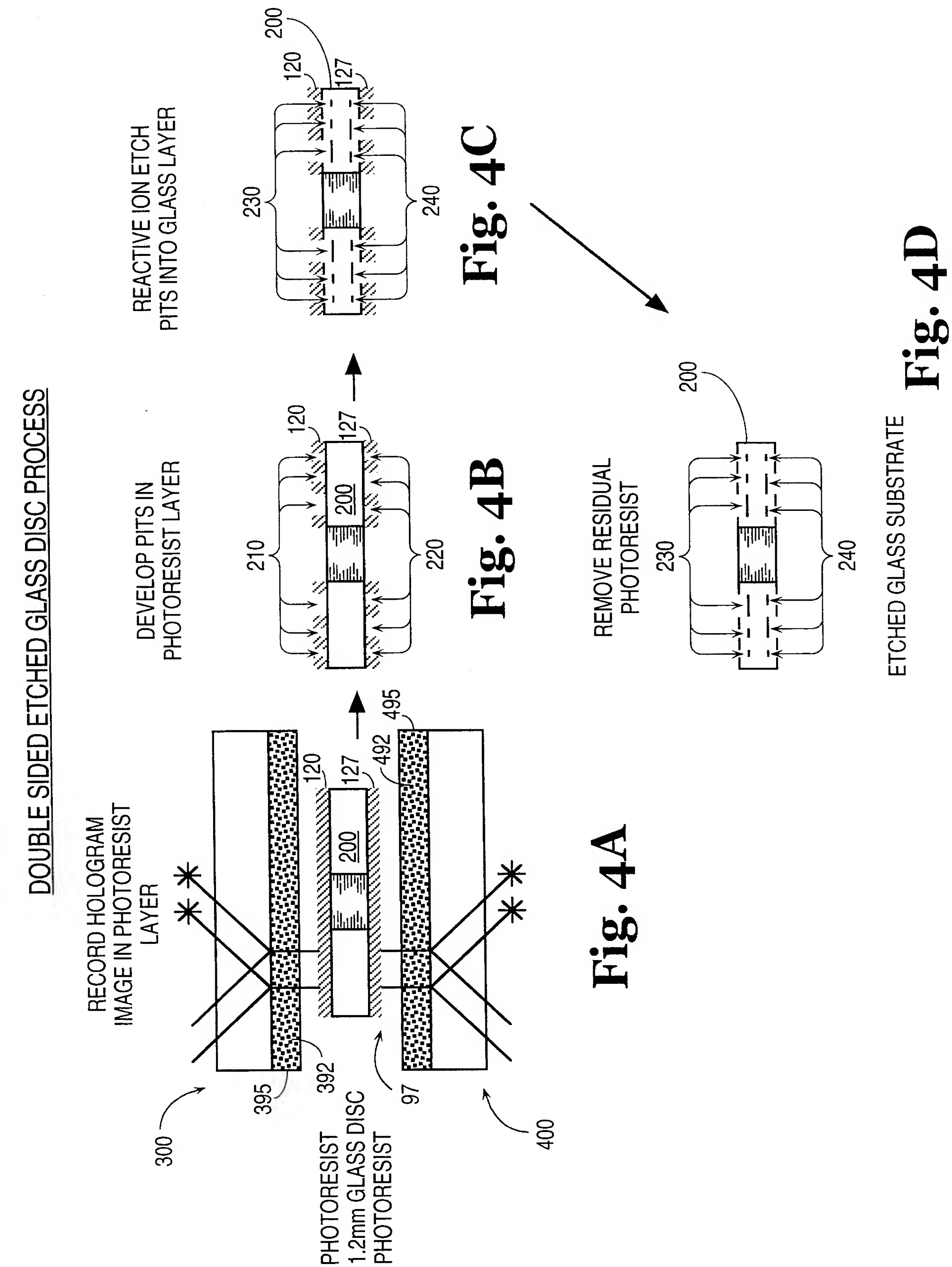

Fig. 4A

Fig. 4B

Fig. 4C

Fig. 4D

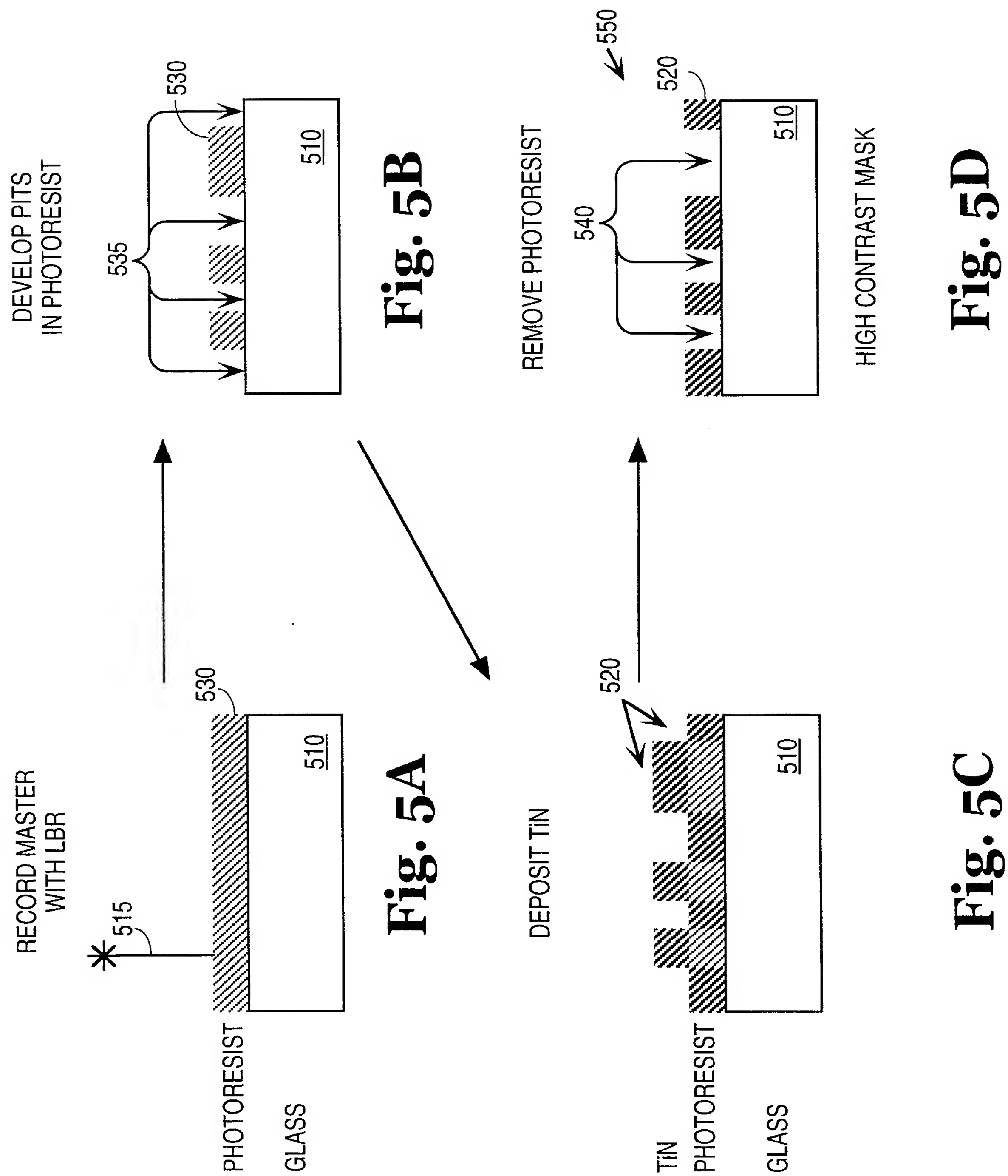

Fig. 5A

Fig. 5B

Fig. 5C

Fig. 5D

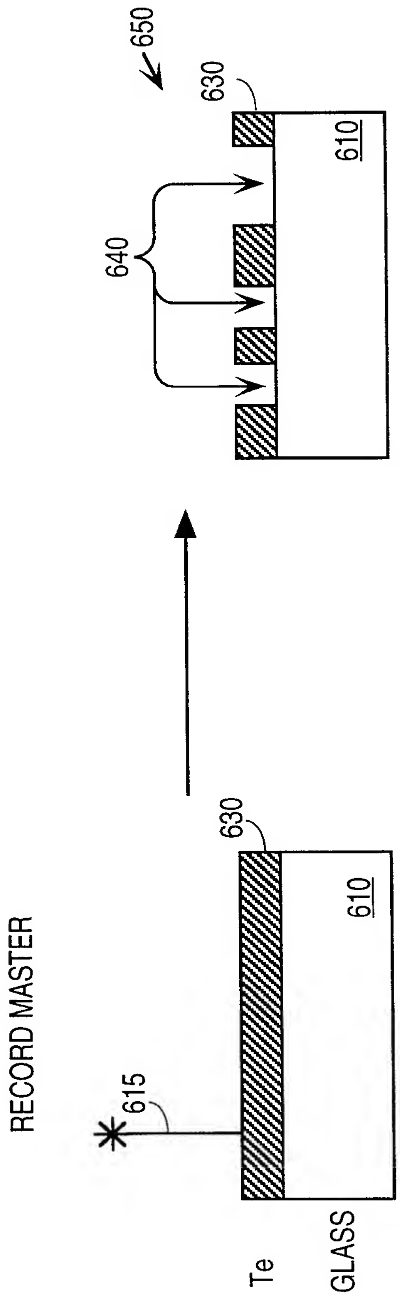

Fig. 6B

Fig. 6A

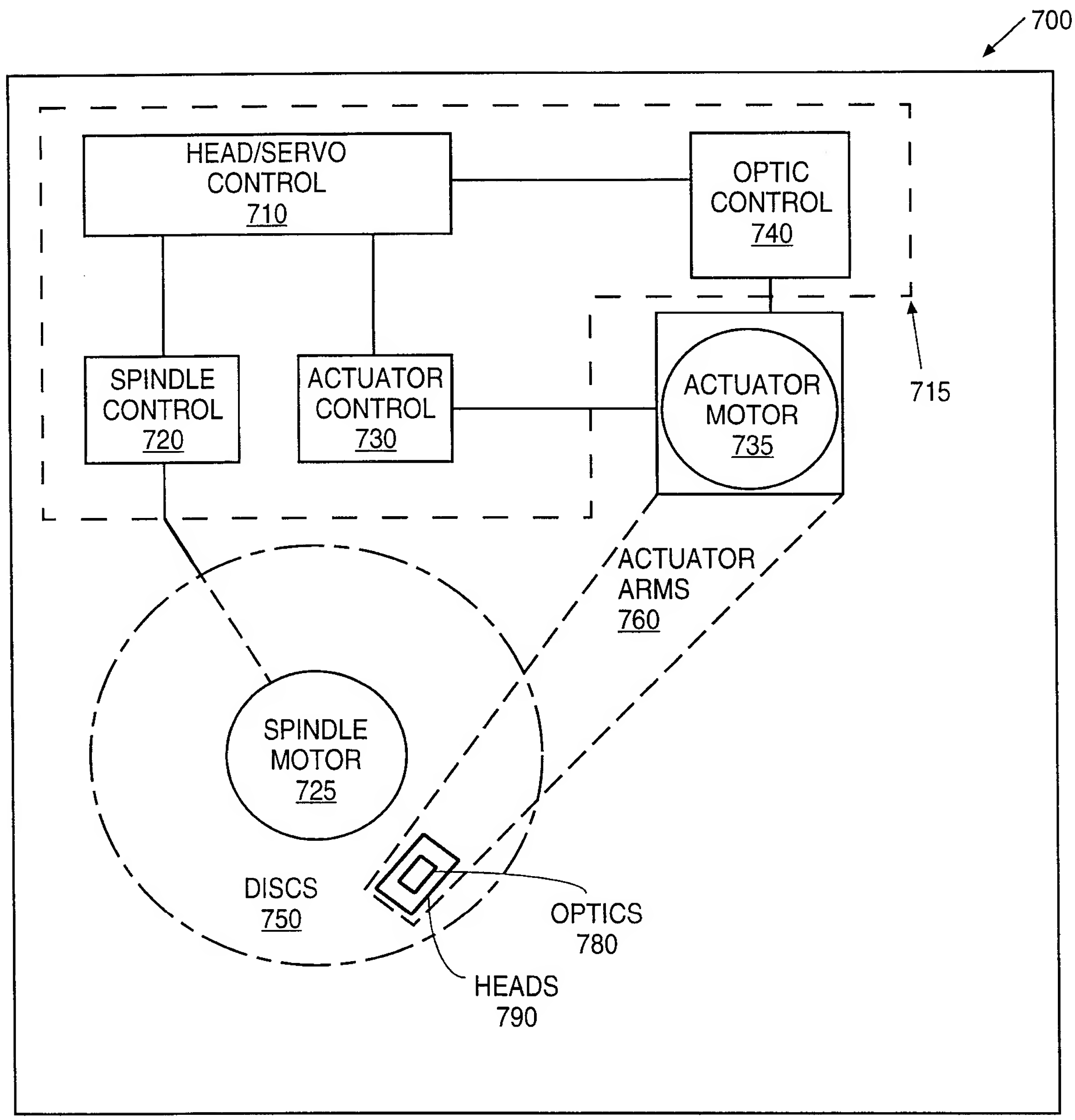
700
HEAD/SERVO CONTROL 710
OPTIC CONTROL 740
SPINDLE CONTROL 720
ACTUATOR CONTROL 730
ACTUATOR MOTOR 735
715
ACTUATOR ARMS 760
SPINDLE MOTOR 725
DISCS 750
OPTICS 780
HEADS 790

Fig. 7

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 99/09544

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 G11B7/26

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 G11B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 271 300 A (EMI PLC THORN) 15 June 1988 (1988-06-15) column 1, line 61 - column 5, line 39; figures 1-3	1-6, 8-10,19, 20,27-31
Y		12,14, 16-18, 21,22,26
X	WO 90 11601 A (GIBSON STEWART HARRY ;HUGLE WILLIAM BELL (CH)) 4 October 1990 (1990-10-04) the whole document	1,3,4, 27-31
Y		14,26
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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
19 August 1999	27/08/1999

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Annibal, P

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INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 99/09544

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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Y	US 5 618 643 A (DAO GIANG T ET AL) 8 April 1997 (1997-04-08) abstract column 6, line 4 - column 7, line 9; figure 2	12
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